4/7 means that a group of 7 things is regarded as a unit group out of which 4 things are taken; and finally gives a proof of the equivalence of 4/7 and 12/21 by means of a graduated scale. This is mixing up three different ways of looking at the matter in a fashion which is very likely to cause confusion. And, so far as his "group" definition goes, he gives it in an imperfect form which is not immediately applicable to improper fractions and which fails to account for the equivalence of a pair such as 4/7 and 12/21.

Another chapter to which we naturally turn is that on irrational numbers and limits. Irrational numbers are treated, after Cantor, as the limits of sequences; and the discussion is satisfactory so far as it goes, though it might well be made rather more complete and is occasionally rather illogical. Thus, for instance, in the early part of the chapter it is said that the ordinary rule for finding a square root, when applied to 2, leads to the inequalities

$$1<\sqrt{2}<2, \quad 1\cdot4<\sqrt{2}<1\cdot5, \quad 1\cdot41<\sqrt{2}<1\cdot42,$$

and so on. As thus stated, the proposition is a pure *petitio principii*. The sequence $(1, 1\cdot4, 1\cdot41, \ldots)$ is convergent, and may be rationally combined with other such sequences according to Cantor's rules; therefore it may be regarded as a number. By definition

$$(1, 1\cdot4, 1\cdot41, \ldots)^2=(1^2, 1\cdot4^2, 1\cdot41^2, \ldots),$$

and this sequence can be proved to be equivalent to 2; therefore $\sqrt{2}$ is an appropriate symbol for $(1, 1\cdot4, 1\cdot41, \ldots)$. We must not begin by assuming the existence of $\sqrt{2}$ as an arithmetical quantity. The proof that sequences obey the laws of operation is put very briefly, and when we turn to the chapter on surds, we find that such an equivalence as $\sqrt{2}\,.\,\sqrt{3}=\sqrt{6}$ is justified, not by the use of sequences, but by a reference to the purely formal law of indices. Here, again, we have a rather unfortunate association of two entirely different notions. If, for any purpose, we like to introduce a symbol θ such that $\theta^2=2$, every rational function of θ can be reduced, by formal processes, to the shape $P+Q\theta$, where P and Q are independent of θ; this is quite independent of the question whether θ can be properly regarded as a number or not; still less does it assign to θ its place in the arithmetical continuum.

Dr. Boyd's chapter on the binomial theorem for any exponent deserves attention, because, although it requires supplementing, it is novel, at least in a text-book, and may prove to be a good way of explaining the theorem to the college student. Let p/q be a positive rational fraction; then

$$(1+x)^{p/q}=\sqrt[q]{(1+px+\tfrac{1}{2}p(p-1)x^2+\ldots+x^p)}.$$

Now it can be shown, as Dr. Boyd indicates without going into detail, that we can, by a process which is, in fact, Horner's method, determine a polynomial

$$y=1+\frac{p}{q}x+c_2x^2+c_3x^3+\ldots+c_mx^m,$$

such that

$$(1+x)^p-y^q=R=Ax^{m+1}+Bx^{m+2}+\ldots+Lx^{qm},$$

where m is any positive integer assigned beforehand. The coefficients c_2, c_3, &c., are numerical, and it can be proved by the method of undetermined coefficients that

$$c_2=\tfrac{1}{2}p(p-q)/q^2, \ldots c_r=\left(\frac{p}{q}-r+1\right)c_{r-1}/r,$$

for $1<r<m+1$. By making m an indefinitely large integer, y becomes an infinite series, which is convergent for $|x|<1$. It remains to be proved that the sum of the infinite series y, when convergent, represents that branch of the function $(1+x)^{p/q}$ which reduces to 1 when x is zero. This last part of the proof Dr. Boyd has failed to supply or even to indicate; the need of it will be seen when it is observed that when y becomes an infinite series, the remainder R is also an infinite series, and it is essential to prove that, as m increases indefinitely, the limit of R is zero.

It will not be amiss to observe that these criticisms, offered with all friendliness and sympathy, are provoked just *because* Dr. Boyd aims at a high standard of logical exactitude. Many a worse book than his may be said to have fewer faults—faults, that is, which lie on the surface and can be pointed out in a few words. To write a really sound book on algebra, not incomprehensible to the ordinary college student, and not hopelessly unscientific when judged from the standpoint of contemporary analysis, is a very difficult task. But it is a worthy one; and the attempt justifies itself, even if it is not crowned with unqualified success. The reader of Dr. Boyd's book cannot fail to gain many fruitful ideas; if he has mathematical capacity he will very likely apprehend them in a substantially correct form, even when the author's exposition is not entirely rigorous.

To sum up, we find in this treatise, as in others of its class, much that is fresh, vital and stimulating; an interest in the progress of research, and in the development of new conceptions; together with a style that is neither frivolous nor pedantic. What we miss is, on the one hand, the German thoroughness which spares no pains to make the logical chain of an argument complete, and, on the other, our English dexterity of manipulation. This last faculty is not of much importance, truly, but is worth reasonable cultivation. It is strange to us, for instance, to find a whole page spent on the decomposition of x^4+px^2+q into a product $(x^2+\alpha)(x^2+\beta)$ without any reference to the fact that x^4+px^2+q is a quadratic in x^2. It is only fair to say that, in this instance, the context partly accounts for the phenomenon; but other examples of needlessly complicated work could easily be given.

G. B. M.

A CANADIAN PIONEER IN SCIENCE AND EDUCATION.

Fifty Years of Work in Canada, Scientific and Educational. By Sir William Dawson, C.M.G., LL.D., F.R.S. Pp. viii + 308. (London and Edinburgh: Ballantyne, 1901.)

LITTLE more than a year has passed since the friends of science and of education in Canada had to mourn the death of Sir William Dawson. Though for the last six years of his life he had retired from his active official duties, his pen was not allowed to remain idle, but continued to throw off papers for scientific journals, addresses to societies and books of a more or less popular kind. One of the occupations of these closing years appears to have been the preparation of a sketch of his own career, which he left complete even to the dated preface

with instructions to his son to have it published as early as might be practicable after his death. Dr. Rankine Dawson has accordingly fulfilled the charge committed to him, and the result is a little volume entitled "Fifty years of Work in Canada, Scientific and Educational."

To those who were privileged with Sir William's friendship or acquaintance, the autobiography will recall many of the traits of his character, many little touches of manner and expression, and many of the moods of thought which showed themselves in his familiar talk. But to those who knew him not, the book will hardly reveal what manner of man he really was. Its readers will learn from it, indeed, that he must have been an enthusiastic student of nature, an upright and earnest and indefatigable teacher, an evidently kindly and genial man who with infinite patience and perseverance, and obviously with consummate tact and skill, fought and won the battle of higher education, for women as well as for men, in a colony where everything had to be begun from the beginning, and where the hindrances and opposition might have daunted a braver pioneer. It traces his life in outline from his boyhood at Pictou in Nova Scotia to his final retirement in the cottage at Little Métis, where, after a slight paralytic seizure in 1897, he quietly waited for the end. But it is no more than an outline, and though interesting as being his own account of himself, it is scarcely adequate as a lasting and final memorial of one who well deserves to be had in remembrance for his services to the geology and educational progress of Canada. Having been delayed till almost the end of his life, the autobiography lacks the freshness and fulness of recent recollection. Sir William met with many interesting and notable men in his time of whom one would fain have had his impressions—such pen-portraits as he probably gave in letters to his friends or family. One would like to know something more of his boyhood and the influences that drew him into the geological field. In a new country, before the days of railroads and coasting steamers, geological expeditions must often have brought a man into strange experiences. Then in regard to educational effort, which lay so close to Sir William's heart and to which he devoted so large a part of his strenuous life, he gives just information enough to make us long for more, that would fill in the details of an interesting struggle of which merely a sketch is given in the book. His published addresses and reports enable us to trace the general progress of his efforts, but naturally they lack the personal element, and the ordinary reader may sometimes fail to realise how much of the advance they chronicle was due to the initiation and persistent energy of the principal of McGill College himself.

Sir William Dawson's original contributions to science range over a considerable field, but the most important of them deal mainly with two departments of geology. He has done more than any other writer to make known the characters and the richness of the vegetation that preceded the luxuriant flora of the Carboniferous period. He speaks regretfully of the refusal of the council of our Royal Society to publish a paper and illustrations which he had prepared on the plants of the Old Red Sandstone, "thereby losing the credit of giving to the world the largest contribution made in our time to the flora of the period before the Carboniferous age." He adds that "a work which had cost me a large amount of time, labour and expense, and which I had looked upon as my *magnum opus*, was not adequately published and probably never will be."

The other branch of geological inquiry which Sir William prosecuted with characteristic energy related to the glacial deposits of Canada. After publishing a series of papers on the subject, he gathered up his results in more connected and popular form and published them in 1894 in his volume on "The Canadian Ice-Age." While glacialists have not generally accepted some of his views of the succession of events, they must acknowledge that recognition is due to the pioneer work by which the facts were first collected and arranged.

Allusion may be made here to another scientific question to which Dawson devoted a great deal of time and thought, though comparatively little reference to the subject occurs in the present volume. His name will always be associated with those of Logan and Carpenter in connection with the *Eozoon Canadense* of the Laurentian limestone. They regarded it as the earliest known trace of animal life, and as probably belonging to the foraminifera. Eventually their views were criticised and opposed, until now the prevailing opinion is adverse to the organic grade of the supposed fossil, but the principal of McGill College appears to have maintained his position to the end.

Sir William Dawson was an eminently religious man and a Christian of the most orthodox Presbyterian type. Though naturally peaceful, he was always ready to lay lance in rest and have a tilt with some adversary of his faith. He never accepted Darwinism. Three months after the appearance of the "Origin of Species" he published his first criticism of the modern doctrine of evolution. From that time, in articles, addresses and books, he continued to express more or less forcibly his dissent. The year before his death he summed up "The Case against Evolution," and in the autobiography which occupied his last days there are occasional indications of his unabated opposition to the opinions "as to the great instability of species, which have been so current among the leaders of the Darwinian evolution." His more popular volumes have had a wide circulation and have been of service in spreading an interest in geology and geological speculation.

The autobiography indicates in general terms that its author led a busy life, but no reader will gather from it an adequate idea of the extraordinary activity of that life. Even the ample list of separate papers which appears in the Catalogue of the Royal Society indicates only one side of his work. To that list must be added a voluminous series of lectures and papers on a wide range of educational, theological and other subjects, and quite a small library of separate books. And all this literary industry went on amid the incessant calls of an onerous official position. We trust that the autobiography may soon reach a second edition, and that advantage will then be taken of the opportunity to add such information as will hand down a fuller picture of the life and work of the late principal. A selection from his letters would be a welcome addition to the volume, likewise a list of his publications arranged year by year. Such a list, prepared by Dr. H. M. Ami, one of Dawson's pupils and a member

of the staff of the Geological Survey of Canada, was published in *The American Geologist* for July 1900. It needs careful revision, but might be made the foundation of a good bibliography. Sir William took so prominent a place in his time that there must be many hundreds of his friends and pupils who, while delighted to have his autobiographical sketch, would be glad to possess a fuller memorial of the man and of his achievements in the cause of science and of education. A. G.

THE FLORA OF INDIA ILLUSTRATED.

Annals of the Royal Botanic Garden, Calcutta. Vol. ix. Part i. *A Second Century of New and Rare Indian Plants.* (Calcutta: 1901.)

WITH the exception, perhaps, of Brazil, the flora of which has been more systematically illustrated, the flora of no country of very large area is so well pictorially illustrated as that of India. Disregarding the earlier publications of less precision, there are the works of Wight, Wallich, Roxburgh, Griffith, Royle and Hooker, and, later, of Brandis, Beddome and others, to say nothing of the very numerous scattered figures of Indian plants.

In 1888 Dr. (now Sir George) King, then Superintendent of the Calcutta Botanic Garden, commenced publishing a new series of quarto illustrations of Indian plants under the title cited above. The first volume contains all the Indian species of Ficus; the second the species of Artocarpus, Quercus and Castanopsis; both by King himself. The third volume is an illustrated monograph of the Indian species of the herbaceous genus Pedicularis, by Dr. D. Prain, the present Superintendent of the Calcutta Garden. The fourth volume is devoted to the Anonaceæ, by King; and the fifth contains a century of orchids, edited by Sir Joseph Hooker, and a century of new and rare Indian plants, by King and P. Brühl. The sixth volume is of a different character, and illustrates some of the microscopic researches of Dr. D. D. Cunningham. The seventh is a fully illustrated monograph of the Bambuseæ of India, by Mr. J. S. Gamble. The eighth volume, nominally, consists really of three thick volumes and comprises 448 coloured plates of Indian orchids, by Sir George King and Mr. R. Pantling. Each of these volumes has been more or less fully noticed in NATURE as it appeared.

The first part of the ninth volume contains a second century of new and rare Indian plants, by King and Prain and Mr. J. F. Duthie, Director of the Botanical Department, Northern India. Remarkable among these novelties are five beautiful species of Meconopsis (Papaveraceæ), thus nearly doubling the number of this essentially Himalayan genus. The specific names, *grandis*, *superba*, *bella* and *primulina*, are suggestive of the ornamental characters which these herbaceous plants possess in a high degree. Unfortunately they are rather difficult to cultivate, but one or two species succeed very well in the rock-garden at Kew. Two or three very fine species of Meconopsis are among the comparatively recent discoveries in western China, and *M. horridula* is one of the most generally dispersed plants in the meagre flora of Tibet, at altitudes of 12,000 to 17,000 feet. Indeed, all the Asiatic species inhabit high levels, and some of them reach the upper limit of phanerogamic vegetation. The only outliers of the genus are *M. Cambrica*, the lowly Welsh poppy, and *M. heterophylla*, a native of California. One of the finest of the species figured in the "Annals," *M. grandis*, is only known from Jongri, in Sikkim, where it is cultivated at altitudes of 10,000 to 12,000 feet, not for its beauty, however, but for the oil obtained from its seeds. Figures are given of three other pretty Papaveraceæ, namely, *Cathcartia lyrata*, *C. polygonoides* and *Chelidonium Dicranostigma*.

From a botanical standpoint the drawings are very good, and the lithography deserves to be rated as excellent. Nearly the whole is the work of native artists.

We have made a point of the new Papaveraceæ, but there are other equally interesting subjects illustrated in this part. New Rutaceæ, Burseraceæ and Sapindaceæ, chiefly by King; Leguminosæ and Labiatæ, by Prain; and alpine Himalayan plants, including new species of Primula, by Duthie.

There is also a proposed new genus of Orobanchaceæ, concerning which particulars of its affinities might have been given. It is named *Gleadovia ruborum*, and was discovered by Messrs. Gleadow and Gamble growing on the roots of *Rubus niveus*, in fir woods, in the North-west Himalaya. The great value of such a publication as the "Annals" can only be appreciated by the working botanist, and it will be of general interest to know that plants of special economic interest will be a feature in the next part. W. BOTTING HEMSLEY.

OUR BOOK SHELF.

Essais sur la Philosophie des Sciences. Analyse, Mécanique. By C. de Freycinet. Second edition. Pp. xiii + 336. (Paris: Gauthier Villars, 1900.)

A GOOD book on the philosophical aspect of space, time, mass and force is rare. M. de Freycinet has produced a work that is both readable and worth reading. It opens with a chapter on space and time in which the essential differences of these two fundamental conceptions are discussed, and the impossibility of forming a quantitative estimate of time except by artificial means is clearly pointed out. The next chapters deal with the notions of infinity, of continuous magnitude, of limits, of infinitesimals and of differential coefficients. In considering the reality of such conceptions, the author is careful to distinguish between reality in a mathematical and in a physical sense, and to point out that reality in the first sense does not necessarily imply reality in the second. Thus the solutions by the calculus of many problems in mathematical physics are based on the assumption that both space and matter are continuous and capable of indefinite subdivision, and these solutions are none the less correct although other phenomena teach us that matter is to be regarded as built up of discrete molecules.

The second part deals with the quantities occurring in dynamics, the laws of motion, the principle of conservation of energy. In it M. de Freycinet has endeavoured in the present second edition to throw greater light on the debated question as to the relative parts played by Galileo and Kepler in the discovery of the laws of motion. According to him these laws consist of (1) the law of equality of action and reaction, due to Newton; (2) the law of inertia, now attributed to Kepler; (3) the law of independence of movements due to Galileo, according to which the relative motion of the parts of a system is unaltered by impressing a common velocity on them; and (4) the law of equivalence of work and heat due to Mayer